Journal of Geosciences, Osaka City University
Vol. 44, Art. 3, p. 41–56, March, 2001

Field Visit to the Neoproterozoic Dom Feliciano Belt, Southeastern Brazil in 2000

Masaru YOSHIDA[1], Leo A. Hartmann[2] and Luis A.D. Fernandes[2]

[1]Department of Geosciences, Faculty of Science, Osaka City University. Osaka 558-8585, Japan (Present address: Gondwana Institute for Geology and Environment, Hashimoto 648-0091, Japan. gondwana@orion.ocn.ne.jp)
[2]Institute of Geosciences, Federal University of Rio Grande do Sul, 91501-970 Porto Alegre, Brazil. afraneo@if.urfgs.br (LAH), Ferna@vortex.ufrgs.br (LADF)

Abstract

Six days field traverse of the Southern Sector of the Proterozoic Mantiquiera Province including the Dom Feliciano Belt of southeastern Brazil was conducted in August 2000. This area is composed of the western Vila Nova Belt which is the Neoproterozoic juvenile accretionary complexes, the central Tijucas Belt which is a Neoproterozoic reworked schist belt of volcano-sedimentary rocks possibly representing a continental magmatic arc, and the eastern Dom Feliciano Belt (*sensu stricto*) which is a Neoproterozoic reworked migmatite-granite terrain with remnants of Paleoproterozoic gneissic blocks. Rocks of these belts are intruded by many late to post orogenic granite masses, and between the first two belts are developed late orogenic Neoproterozoic basin sediments. Some good outcrops of all geologic units were visited, resulted in the collection of field observations and rock samples. A brief review of the present knowledge of this belt, and field observations of several important outcrops accompanied with several field photographic pictures are given.

Key-words : Dom Feliciano Belt; Brasiliano orogeny; Vila Nova Belt; Tijucas Belt; Pelotas Batholith

INTRODUCTION

Understanding the fundamental geotectonic structure of an orogenic belt is principally important for reconstructing the crustal evolution of the belt. Recent geological, structural and geochronological studies in the Southern Sector of the Neoproterozoic Mantiquiera Province (Dom Feliciano Belt of *sensu lato*, Fig. 1) provide us with important clue to understand the tectonic evolution of Gondwanaland, especially the collision between the southern part of South American (Rio de La Plata and some other cratons) and African (Kalahari) cratons.

It was timely at the present state of knowledge (e.g., Basei et al., 2000; Trouw et al., 2000) on the Dom Feliciano Belt within the Gondwana assembly, that 31st IGC in Rio de Janeiro in August 2000 planned a field excursion to the Dom Feliciano Belt to demonstrate the geologic characteristics of this belt. The field excursion of 6 days was organized by scientists of the Federal University of Rio Grande do Sul (UFRGS), including two of the present authors (LAH and LADF). Observations and discussions in the field associated with detailed explanations by field leaders based on recent and on-going knowledges, supported by a bunch of related 28 papers totaling about 500 pages given to all participants were so excellent that the senior author have ever had. Further detailed discussions with some scientists of UFRGS made by chance of additional visit of the Senior author to the university after the field trip facilitated him to further obtain a better understanding of this important Brasiliano mobile belt, in its recent vivid picture of collisional tectonic regime as well as existing contradictions among understandings of scientists.

The major contradiction in understanding the evolution of this belt includes group of ideas whether the three geotectonically different belts were juxtaposed by a principally single Brasiliano Orogeny or by two different orogenies. Within the former group, some consider the eastward subduction (e.g., Porada, 1979; Fragoso-Cesar, 1980, referred after Basei et al., 2000) and some others consider westward subduction (e.g., Fernandes et al., 1992: Frantz and Botelho, 2000). For the latter group, Fernandes et al. (1994) considered the same eastward polarity of two subductions, while Chemale (1998) proposed early eastward and later westward subductions. There are some other important inconsistencies, i.e., tectonic characterization and age of Pelotas granite (Frantz and Botelho, 2000; Leite et al., 1998; Silva et al., 1999a).

GEOLOGIC SETTING

Proterozoic terrains in southeastern Brazil and Uruguay south of the São Francisco Craton have been called the Mantiqueira Province which have been divided into the Northern (the Araçuai Belt), Central (the Ribeira Belt) and Southern (the Dom Feliciano Belt *sensu lato*) sectors (Almeida and Hasui, 1984). The Southern Sector is generally regarded to be the continuation of the Damara and Gariep belts in southwestern Africa and the Saldanian Belt further south in southern Africa (Fig. 1, Hartman and Fernandes, 2000).

The name Dom Feliciano Belt (*sensu lato*, e.g., Basei et al., 2000) was first introduced by Fragoso Cesar (1980) including all the geologic units within the Southern Sector of the Mantiquiera Province and this belt was considered to form a westward subduction system during the Brasiliano Orogeny. Later geological, petrological and geochronological work contributed in improving and revising the tectonic model of the belt (e.g., Basei et al., 2000; Hartmann and Fernandes, 2000, and references therein), although there are varieties of ideas and a concrete geotectonic model is as yet to be proposed.

The Dom Feliciano Belt of *sensu lato* is composed of three distinct geotectonic units (Fig. 1). They are the juvenile Neoproterozoic Vila Nova Belt (São Gabriel Block in Fig. 1), the possible Neoproterozoic continental magmatic arc Tijucas Belt (Porongos Belt), and the Dom Feliciano Belt *sensu stricto* (mostly coeval with the Pelotas Batholithic Complex) composed of reworked granitic and gneissic rocks (Chemale et al., 1995; Chemale, 1998, Basei et al., 2000, Hartmann and Fernandes, 2000, and references therein). To the west of the Dom Feliciano Belt of *sensu lato* are wide development of Parana Basin sediments where discontinuous exposures of Paleoproterozoic basement rocks composed of the Luiz Alves Craton in the northern area and the Rio de La Plata Craton in the southern area occur.

The Luiz Alves Craton and the Rio de La Plata Craton are generally considered to form the single Rio de La Plata Craton. Circa 2.35-2.01 Ga high-grade metamorphism and granite activity are identified in these cratons (cf., Basei et al., 2000). These cratons are composed of several different blocks of different geotectonic signatures (Basei et al., 2000). For example, they clearly identified the Luiz Alves microplate from the northwestern Curitiba microplate, which is mostly covered by Neoproterozoic sequence of the Ribeira Belt. Crustal blocks forming the basement of the Dom Feliciano Belt (*sensu stricto*) is also regarded separate from the Rio de La Plata Craton (e.g., Chemale, 1998; Soares et al., 2000).

Late orogenic Morassic Neoproterozoic sedimentary basins develop mostly in the western part of the belt. Late and post orogenic granitic and rarely, basaltic, and alkaline intrusives are found throughout. The above geologic units are considered to be mostly continuous from the southern typical area in the Rio Grande do Sul and Uruguay to the northern area surrounding Florianopolis (Chemale et al., 1995; Basei et al., 2000; Hartmann and Fernandes, 2000). All the above geologic units are covered by the Phanerozoic sediments of the Parana Basin to the west. A part of the Parana sediments protrudes eastward up to the Atlantic coast with a width of nearly 400 km and thus divide the Dom Feliciano Belt (*sensu lato*) into the northern Santa Catarina area surrounding Florianopolis and the southern Rio Grande do Sul and Uruguay area surrounding Porto Alegre and south of it (Chemale et al., 1995; Basei et al., 2000; Hartmann and Fernandes, 2000).

Two major deformational-metamorphic events have been recognized in the Southern Sector of the Mantiqueira Province during the Brasiliano period: the earlier São Gabriel events (ca 700-750 Ma) and the later Dom Feliciano events (ca 600 Ma) (Chemale et al., 1995; Babinski et al., 1996; Chemale, 1998; Basei et al., 2000; Hartmann and Fernandes, 2000), the former dominating in the Vila Nova and Tijucas belts, and the

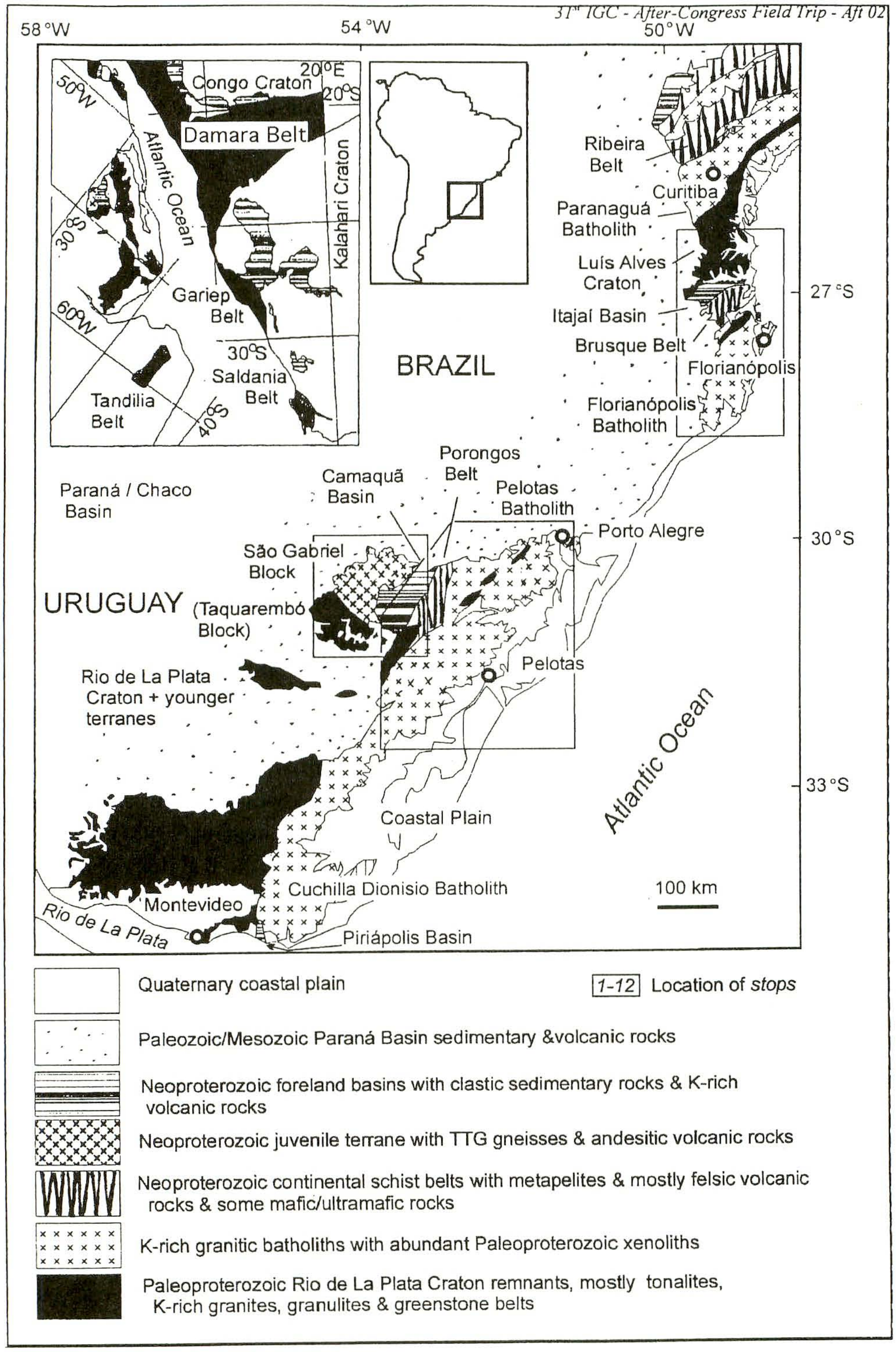

Fig. 1 Dom Feliciano Belt and surrounding areas in southeastern Brazil and Uruguay (Cited after Hartmann et al., 2000). Field observations were made in framed areas.

latter occurring mostly in the Dom Feliciano Belt (*sensu stricto*).

The Vila Nova Belt (also called the São Gabriel Block) is a Neoproterozoic accretionary prism composed of the Cambai (ca 900–700 Ma) and the Vacacai (ca 750–700 Ma) complexes (Chemale et al., 1995). The Cambai Complex includes the Vila Nova Sequence made up of tonalites-trondhjemites, granodiorites, marbles and amphibolites exhibiting the root of an island arc, and the Cerro Mantiqueiras

Sequence contains mafic-ultramafic rocks including ophiolites. The Vacacai Complex is made up of acid to intermediate volcanic and volcaniclastic rocks and associated sedimentary rocks. They are intruded by post tectonic K-rich granitic rocks and altogether are affected by deformation and metamorphism under the amphibolite facies conditions. The Vacacai Complex is considered to represent a juvenile volcanic arc. Dating of rocks of this belt were conducted by Machado et al. (1990, conventional zircon U-Pb), Babinski et al. (1996, conventional zircon U-Pb and Sm-Nd systematics), Remus et al (1999, SHRIMP) and Leite et al. (1998, SHRIMP). They obtained ca 750 Ma ages from metavolcanic rocks of the Vacacai Complex: an older age of ca 879 Ma was reported (Leite et al., 1998) from metadiorite of the Cambai Complex.

The Tijucas Belt includes the Porongos Schist Belt in the southern area. The Porongos Schist is made up of low-grade schists of pelites, felsic volcanics, marbles and calc-silicate rocks. Ultramafic rocks also occur and seem to be a part of dismembered ophiolite. All of these rocks are affected by deformation and metamorphism of greenschist facies conditions. Schists of this belt had been considered mostly Mesoproterozoic. However, ca 773 Ma zircon U-Pb (Chemale, et al., 1997), ca 780 Ma SHRIMP (Porcher, et al., 1999, referred after Frantz et al., 2000), and a Rb-Sr whole-rock isochron ages of ca 884 Ma with a low Sr initial ratio (Soliani Jr., 1986, referred after Frantz et al., 2000) for the magmatic rocks were obtained from the Porongos schist. Older inherited ages up to ca 2112 Ma from metavolcanic rocks of the Porongos Complex were obtained, indicating older crustal component in this belt.

The Brusque Schist was regarded to be the continuation of the Meso- and Neoproterozoic Polongos Schist and altogether form the Tijucas Belt (e.g., Chemale et al., 1995). However, recent zircon SHRIMP data place the magmatic age of a metadacite of the Brusque Belt at ca 2.6 Ga (Hartmann and Fernandes, 2000). This casts a doubt for the above correlation.

Rocks of the Tijucas Belt show Neoproterozoic age, but their zircon SHRIMP ages (Porcher et al, 1999) show distinct evidence of Paleoproterozoic components. The above characteristics prompted Chemale (1998) to consider that this belt was a continental magmatic arc of Neoproterozoic age. The basement of the Tijucas Belt is considered to be the Paleoproterozoic Encantadas Complex gneisses, which occur in the core of an anticline in the eastern part of the belt.

The Dom Feliciano Belt *sensu stricto* is mostly composed of the Neoproterozoic Pelotas Batholith with minor occurrences of the Paleoproterozoic Encantadas Complex in the western part of the belt. In the northern area, the Florianopolith Batholith has been regarded to be the continuation of the Pelotas Batholith. The Pelotas Batholith is composed of syncollisional high-K calc alkaline granites and migmatites (the Pinheiro Machado Suite) of ca 650 Ma-610 Ma and late- to post-collisional granites (Encruzihada Suite) of ca 555-540 Ma (Silva et al., 1999). Nd model ages and zircon conventional (Babinski et al., 1997) and SHRIMP (Leite et al., 1998; Silva et al., 1999) ages, however, show dominant contribution of Paleoproterozoic material in this belt, and Rb-Sr dating shows dominance of distinctly older ages of ca 800 Ma (Franz and Botelho, 2000).

The geochemical study by Frantz and Nardi (1992) indicated that this belt formed a magmatic arc developed at active continental margin. Recent detailed geochemical as well as geochronological (Rb-Sr) study of Frantz and Botelho (2000) also brought out a collisional origin of the Pelotas granites, and suggested a westward thrusting tectonics caused by the collision. Chemale (1998) considered that a westward subduction of the Kalahari plate under the Encantadas Microcontinent formed a magmatic arc of the Dom Feliciano Belt, representing the Dom Feliciano event during ca 650 to 590 Ma, including the earlier thrusting and later transcurrent tectonics. However, Frantz and Botelho (2000) considered that the major episode of the syncollisional granite (the Pihneiro Machado granite) is ca 800 Ma, and the syn-transcurrent granites range from 672 Ma to 617 Ma.

Thus, there are controversies in understanding the tectonic positioning of the Pelotas Batholith. The Florianopolis Batholith is composed of syn-collisional transpressive granitoids of high-K calc-alkaline signature, late to post transcurrent granitoids of high-K calc-alkaline granitoids, and post-tectonic peralkaline granites and minor alkaline and shoshonitic rocks.

The Florianopolis Batholith has been regarded to be the continuation of the Pelotas Batholith, both forming the Dom Feliciano Belt (*sensu stricto*) as mentioned above. Silva et al (2000), however, found systematic older ages of granitic masses of the Florianopolis Batholith in comparison to those of the Pelotas Batholith, and considered that the Florianopolis Batholith does not belong to the Dom

Feliciano Belt but to be included in the Ribeira Belt which lies to the northwest of the Florianopolis area.

The late tectonic basin (ca 600 Ma) develops at around the boundary between the Vila Nova Belt and the Tijucas Belt. These sediments developed specifically at this tectonic stage have been called together as the Camaqua Basin sediments. They are flat-lying and undeformed except those in the transcurrent Piquiri Basin in the west. These basin sediments formed during the time near the end of the Brasiliano Orogeny (ca 600 Ma), and are considered to have formed simultaneously with those of the Nama Basin of SW Africa (Gresse et al., 1996).

The late to post tectonic granitic masses are distributed throughout all the geologic units mentioned above. They form the largest volume of the Florianopolis Batholith in the northern area and of the Pelotas Batholith (Pinheiro Machado Suite) in the southern area. These are mostly K-rich granitic rocks of crustal derivation. Peralkaline granites that are mostly Na-rich but some are K-rich occur in both northern and southern areas as small plutons. This is the Serra do Mar Suite in the northern area, Encruzilhoada Suite in the southern area, and Saibro Suite in the São Gabriel Block. Alkaline shoshonitic rocks of this stage are also found in the São Gabriel Block as well as in the Florianopolis area.

FIELD OBSERVATIONS

The field trip Aft 02 of 31st IGC, "Crustal Evolution of Southern Brazil: Juvenile Accretion and Shear Zones" (Hartmann and Fernandes, 2000) was planned to cover a complete transect of the Dom Feliciano Belt (*sensu lato*) from its northwestern boundary between the Luiz Alves Craton (Archaean and Paleoproterozoic) surrounding Florianopolis, to the centre of the Dom Feliciano Belt (*sensu lato*) in the south around Porto Alegre and further southern area. In the following, field observations of major outcrops of each geologic unit are given. The field observations are separated into those in the northern area surrounding Florianopolis and in the southern area surrounding Port Alegre and further south.

Departing Rio de Janeiro very early in the morning of 18th August 2000, the senior author arrived Florianopolis Airport at about 9:00 where he was met by L. A. Hartmann, the principal leader of the present field trip. A fairly big and convenient bus was arranged for the field trip. Total participants were 9 apart from field leaders. The participants included 3 Germans, two Chinese, and one each of Australian, Brazilian, Japanese and Lithoanian.

<The northern Area Surrounding Florianopolis>

The Luiz Alves Craton

A fresh and beautiful outcrop of pyroxenite cropping out at the coast of Barra Nelha at about 120-km north of Florianopolis was visited on 18th August, the first day of the field trip. The pyroxenite is said to be metamorphosed under granulite facies. However, there were poor indications of metamorphism at this specific outcrop. A basic dyke with chilled margins cuts across the pyroxenite. The pyroxenite is composed of porphyroblastic hornblende embedded within finer grained two pyroxenes. According to the field leader, M1 is indicated by the polygonal matrix of two pyroxenes, M2 by hornblende which alters pyroxenes, and the M3, by symplectic fine aggregates of two pyroxenes rimming the hornblende. Field evidence of the granulite facies metamorphism is said to be seen at the boundary area of the pyroxenite with the country granulites where the pyroxenite becomes boudinaged within the granulites and both carry same penetrative foliation made of the granulite facies mineral assemblages.

An abandoned quarry along the highway near Luiz Alves was visited. The name of this town is well known to Brazilian people as the best sugar cane product for beautiful "pinga" (special Brazilian liquor) as well as to Gondwanan Scientists as the origin of the name of the Luiz Alves Craton. Thus, what we observed here was the type locality for the granulites of the craton. It is mostly of trondhjemitic granulite with numerous mafic enclaves as blocks, pods and bands, and granitic pools and bands all of which often give good banding structure to the rock which trends N65E and dips 60 towards north in general. The mafic enclaves are considered to include similar type rocks with the pyroxenite mentioned above, although the lithology observed in the field this time does not strongly conform with it.

The Brusque Complex

The Brusque Schist was visited on the second day, on 19th August. All three stops were low-grade schists of the Paleoproterozoic (?) Brusque Complex along the coast surrounding Itapema to Camboriu. The pelitic schist carries near-horizontal structure, which includes recumbent isoclinal folds and horizontal shears, all of them having been affected by later

Fig. 2 Brusque Schist showing gentle foliation including recumbent-isoclinal folds which are superimposed by open small folds with steep axial surfaces and associated cleavage

Fig. 3 Flat lying Brusque Schist with a granitic sheet. Coastal outcrop in the Hotel Plaza Itapema

Fig. 4 Dark gray rhyolite of latest Proterozoic age at the Pumtam de Sol of Island Florianopolis

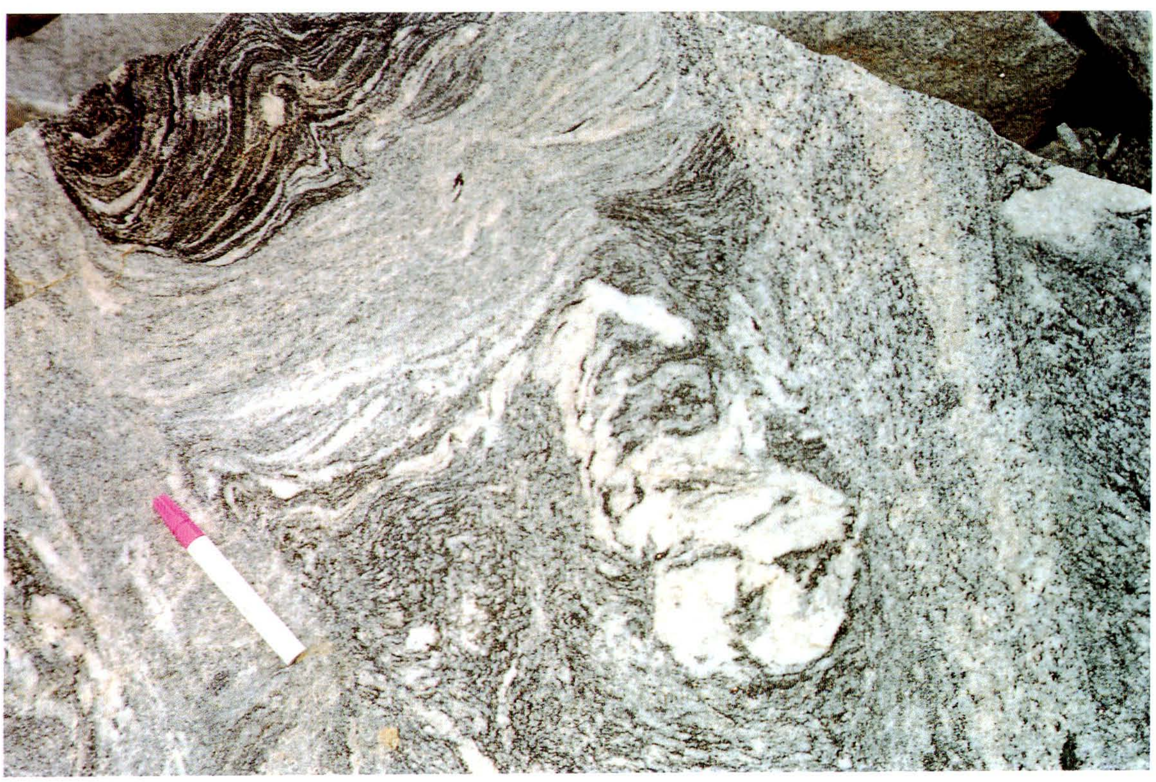

Fig. 5 Transamazonian gneiss showing multiple migmatization-structural episodes. The latest granitic bands on the right may represent the Brasiliano event

open to close folds with axial surface trending E-W and dipping steeply to the south (Fig. 2).

The lithology and structural characteristics of the schist appeared just similar as the Sambagawa Schist in

Japan as well as some greenschist in the Ribeira Belt in the Itapema area where the senior author visited last year. Rare chert, limestone, and calcareous shale layers are completely boudinaged and dismembered showing as if the rock is pebbly shale. Well foliated greenschist in the east coast about 1 km east of the metapelitic schist of the above outcrop shows good development of overturned to recumbent folds which are cut by later open small folds as was the case of the pelitic schist. Axial planes of the major fold run E–W with gentle to mild dip towards north, carrying distinct undulation lineation plunging gently east.

A beautiful coastal outcrop in the Hotel Plaza Itapema is mostly greenstone, calcsilicates and graywacke schists poorly carrying microfolds. Gentle to horizontal shear planes develop with distinct NW lineation, along which a quartzofeldspathic granite sheet of about 40 cm thick intrudes (Fig. 3). The granite carries clear contact effect shown by the growth of coarse-grained biotite within one centimeter from the contact with the graywacke schist. Later quartz veins associated with shearing affected all the above structures. There is a poor indication of the F2 folds, which was very clear in the former two outcrops.

The Florianopolis Batholith

A fresh and beautiful outcrop at Pumtam de Sol of Florianopolis Island (Fig. 4) is dark gray rhyolites almost non-metamorphic but carrying some non-penetrative cleavages. The time of the emplacement is considered to be at around 600 Ma, judged from the age of the possible cogenetic A-type granitic rocks developed extensively throughout the area. These granites are also said to carry non-penetrative shears, which was dated by SHRIMP at about 590 Ma of rim of zircons, the core of the zircons giving the Transamazonian age of ca 2.1 Ga (Silva, et al., 2000).

Two big quarries of mixed Neoproterozoic granite and Paleoproterozoic gneiss were visited. One outcrop lies about 5 km W of Itapema, and the second, 5 km north of Itapema. They are both characterized by numerous relic blocks of Transamazonian banded (hornblende) biotite gneiss intruded by abundant schistose to non-schistose medium-grained monzonogranite (Fig. 5). A pink variety is often massive, and contains digested enclaves of the gray schistose variety.

<The Southern Area>

A long drive of 600 km on the second day after field observations brought us to Porto Alegre, the capital of Rio Grande do Sul State. It was early morning 1 : 20 of 20th August. After some sleep, we departed the hotel at 9:00 AM of the same day. On this day, we crossed almost all the Dom Feliciano Belt of *sense stricto* by the big bus.

Paleoproterozoic Encantadas Complex

The first outcrop of 21st August the 4th day of the field trip is located near Santana da Boa Vista, some hundred meters away from the highway and in the beautiful riverbed under the Arroio Moinho Bridge. It is the Encantadas Complex gneisses with zircon U-Pb SHRIMP magmatic age of 2.25 Ga and metamorphic age of 2.03 Ga (Porcher et al., 2000) over which we took a group photo (Fig. 6). The predominant rock exposed here is banded hornblende biotite gneiss which is well banded by quartz-feldspathic rich and mafic rich bands. Although the gneiss is well banded, the rock appeared to be igneous origin (tonalite?) due to the homogeneity of structure and texture. Mafic part is composed of biotite and possible amphibole and chlorite, judged from its greenish color. Pinkish pegmatite-aplite veins occur, co-folded with the gneissic bands. Both the gneiss and the pegmatite have tonalitic composition.

Second outcrop was an unscheduled stop of Paleoproterozoic basement gneiss (Arroio dos Ratos Orthogneiss) located along the highway at about 5 km NW from the first outcrop. The rock exposed here is well-laminated cryptocrystalline to glassy acid rock said to be quartz mylonite of granitic rock origin (Fernandes, Personal com), with mylonitic coarse-grained biotite granite bands of a few meters thick. The fine-grained rock carries flattened quartz phenocrysts and scattered mafic phenocrysts; the latter is now stained to show many holes in the rock. As such the rock appeared as if it is mylonitized rhyolite or dacite and not the granite origin.

After driving some tens of kilometers, we entered into the São Gabriel Block area. The 3rd outcrop was at about 10 km S of Cassapava, in the river beds about 500 m W from the highway. It is blasto-protomylonitic K-rich granite of Paleoproterozoic magmatic age (2.45 Ga) with a Brasiliano metamorphic age (0.56 Ga) by zircon SHRIMP method (Hartmann et al., 2000), said to form the Neto Rodrigues gneisses. The gneiss is well banded by quartzo-feldspathic and mafic bands; but still protomylonitic texture is found in various parts of the rock. S (N10E30E) and L (N55E20) structures develop, the latter being composed of crenulation-like structure of the s-plane.

Fig. 6 The field party, on the granodioritic gneiss of the Encantadas Complex, at the riverbed under the Arroio Moinho Bridge

Fig. 7 Tonalitic gneiss of the Cambai Complex near São Gabriel

The Vila Nova Belt of the Sao Gabriel Block

On the later half of 21st August, we visited the Neoproterozoic Juvenile belts of the São Gabriel Mountains. The fifth stop of the day was a roadside

Fig. 8 Pelotas Granite, carrying subhorizontal foliation and later vertical mylonitic bands

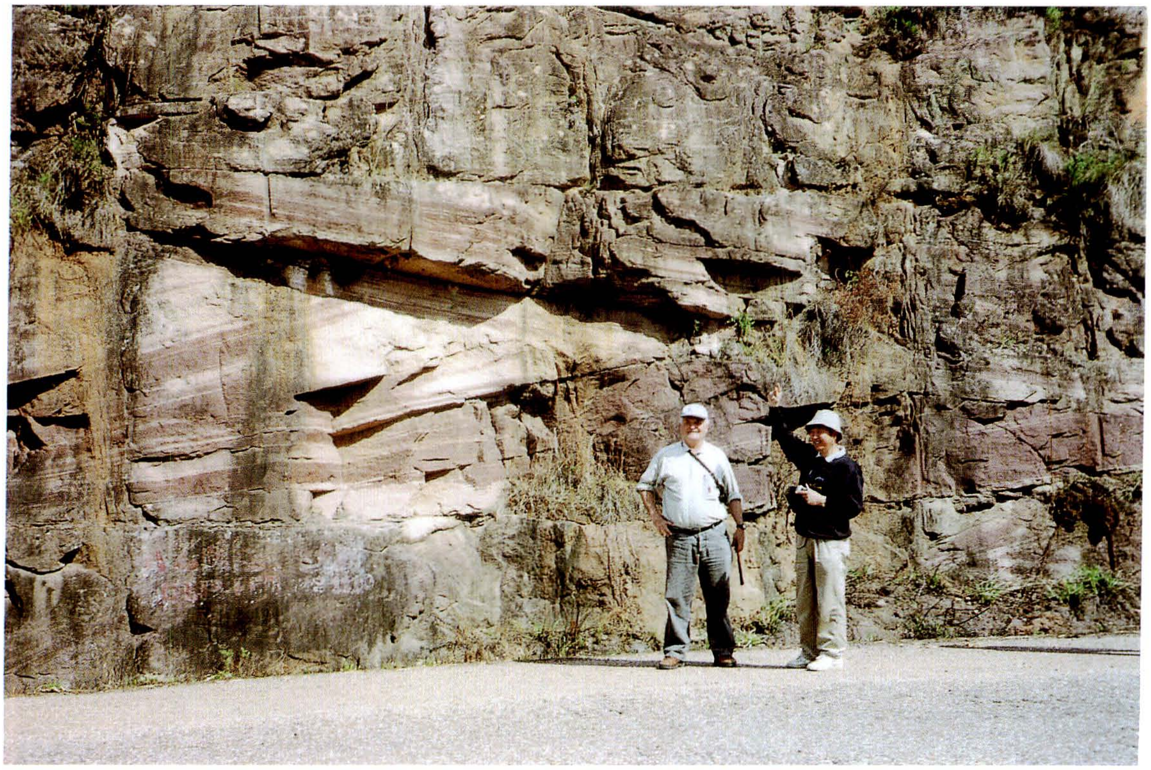

Fig. 9 Ordovician sandstone of the Neoproterozoic Camaqua foreland basin showing beautiful cross bedding structure

outcrop near São Gabriel. The rocks here include amphibolite of basaltic origin sometimes carrying amygdules, talc-chlorite-tremolite schists of high-Ti fertile komatiitic rocks origin, and staurolite-sericitechlorite schist of pelitic origin. These rocks belong to the Vacacai Complex of the Cambaizinho Sequence. They have the T_{DM} age of no older than 1.3 Ga and carry zircons of ca 750 Ma age (Soliani Jr., 1986; Babinski et al., 1996; Leite et al., 1998), and form a well- documented juvenile crustal unit in this area. Actually these rocks along with the beds of the Cambai Complex of the next outcrop are one of two definite juvenile material throughout the Brasiliano belts in South America (another one occurs in Goions of NE Brazil). Most of the rocks carry schistosity (N35°-45°E) and two lineations (N50°-55°E30° and S60°E 60°), the latter being discordant from the hinge (N60E40) of an observed small tight fold.

The sixth outcrop was amphibolite and tonalitic-granodioritic rock with biotite gneiss and amphibolite as enclaves, composing part of the Cambai Complex Granitic Gneiss (Fig. 7). It forms the juvenile crust of an island arc type with magmatic zircon age of ca 700 Ma (Babinski et al., 1996). The banding trends N60E and dips 50° S, and undulation lineation (S50°W 5°) develops over it. The seventh outcrop was an unscheduled stop at the outcrop of the Vacacai Group. The rocks exposed here are calc-alkaline low-K andesite, basic andesite, dacite, and possible pelites, all of which are schistose, and distinctly weathered. These rocks are said to belong to the ca 760 Ma age group. One granite pebble or dike is found within the andesite. Quartz veins cut across the rocks. All rocks carry penetrative schistosity and mineral lineation plunging N30°E25°.

The Pelotas Batholithic Complex of the Dom Feliciano Belt (*sensu stricto*)

It was 20th August, the 3rd day of the field trip when we visited Guiaba, about 20 km south of Porto Alegre, along the highway Br 116 and then drove on a small road for about 10 minutes. It is a big working quarry of weakly sheared and partly foliated high- potassic granite of ca 600 Ma of zircon SHRIMP ages (Kestrel et al., 2000). The granite sporadically carries weak mylonitic foliation trending N60°W and dipping steeply north, exhibited by elongation of quartz and mafic clot. The mafic clot is composed of possible hornblende core rimmed by aggregates of fine biotite. K feldspar is medium to very coarse grained, pinkish red, and equant. Later heterogeneous shearing partly affected the rock to loose the reddish color and gave the protomylonitic appearance to the rock, as well as some alteration of minerals. The shear trends N70°W and nearly vertical. Distinct block shearing of the quarry resulted in the development of chlorite-epidote- quartz films along block surfaces.

The second stop was after a long drive of about 200-km to the south, at 30-km west of Pelotas. A granite quarry with a big pond at the roadside was visited. It is foliated (with remnant of biotite gneiss) potash-feldspar porphyritic granite, explained as the syncollisional granite and migmatite. The potash granite carry gentle foliation composed of dark seams, elongated mafic clots and leucocratic pools which are transected by sporadic vertical shears and mylonitic bands of 1mm to 100 mm wide (Fig. 8). The foliation trends N30E and dips 20 to 40 towards NW. The mylonite carries a chlorite quartz assemblage.

The third outcrop was a road cut along the same highway 30-km northwest of the previous outcrop. At this outcrop the partial melting of xenolithic tonalitic rock to produce the high potassic granite were examined (Soares et al., 1998). The granite here sporadically carries xenolithic blocks of dark banded amphibolitic rock, which is said to be the biotite tonalite. Distinct gentle foliation trending N60°W and dipping NE35° develops throughout; the foliation is composed of relict seams of biotite gneiss. This foliation in this outcrop as well as the previous one was explained to be the flow foliation of the magmatic stage. However, they appeared apparently the relic structure of xenolithic biotite gneiss.

The Late- Post-tectonic Camaqua Basin Sediments

In the northern São Gabriel Mountains along the road, the base of the Camaqua Basin was observed late on 21st. It was an alternation of shale and shaley sandstone with ripple mark showing very shallow beach condition (Ulf Linnemann, Personal comm). Ca 560 Ma granite is said to intrude this unite.

The next unscheduled stop was about 20-km NW from the previous outcrop, situated in the midst of the Neoproterozoic Camaqua foreland basin. It is a road-cut outcrop composed of beautiful large-scale cross-laminated sandstone of light gray and brown alternations (Fig. 9), belonging to the Camaqua Basin fillings of Ordovician age (470 Ma).

Piquiri Neoproterozoic Strike Slip Basin

It was 22nd August, the fifth day of the trip, that we observed outcrops of sedimentary rocks within the Piquiri strike-slip basin surrounding Pieiros which forms one exceptionally deformed basin of the mostly non deformed Camaqua basins.

The 1st stop was a panoramic view of the Piquiri Valley with the rhythmites in the valley ahead (W) and ridges of conglomerates to SW (Fig. 10). The 2nd outcrop was a cross-section of the sequence I along the southern segments of the Piquiri Basin, poorly exposed along the road surface and roadside. Basal foliated conglomeratic breccia and rhythmites of Sequence I were observed. The

Fig. 10 Piquiri Valley where the Neoproterozoic Piquiri transcurrent basin sediments develop. The flat valley is filled by fine sediments whereas the ridges are occupied with conglomerate beds

Fig. 11 Conglomerate beds of the Piquiri strike slip basin

fine-grained rocks carry diagenetic white mica, which may be a good candidate to give the age of diagenesis. The schistosity /cleavage structure of the diamictite may or may not carry micas. The pebble/breccia of this rock is mostly

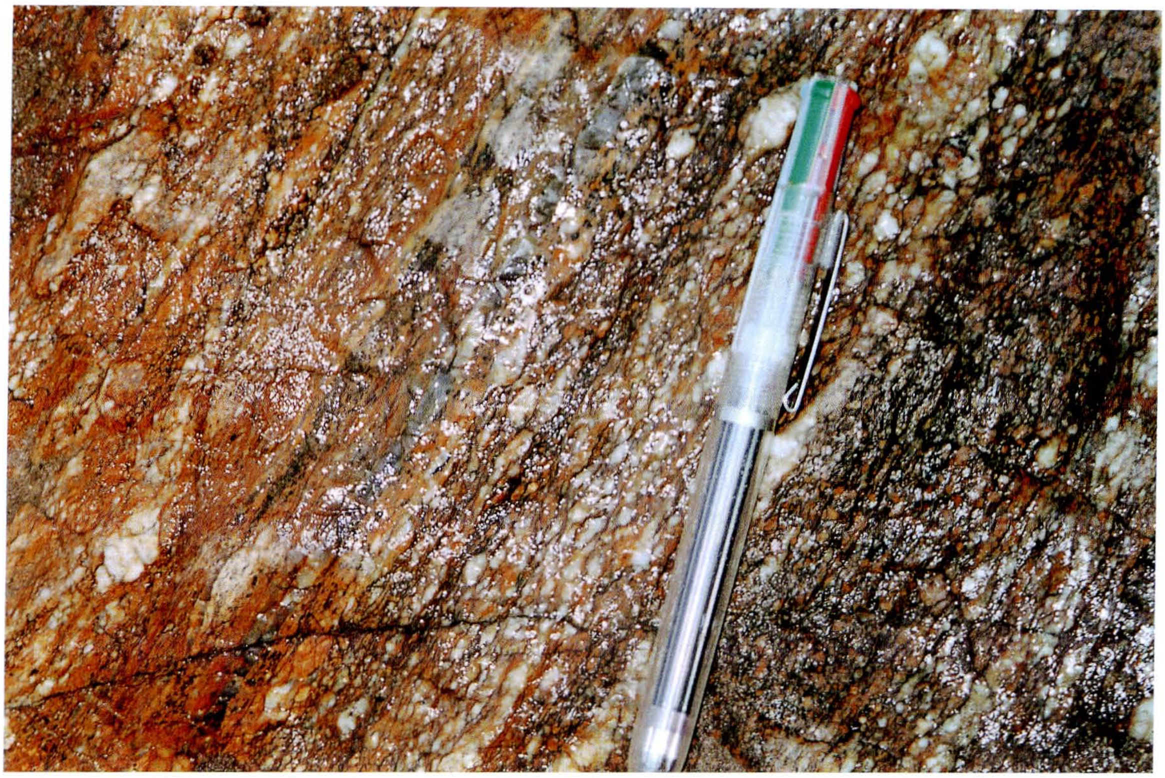

Fig. 12 Mylonites of granodioritic to tonalitic composition along on the river bed in the Dorsal Cangussu Shear Zone

Fig. 13 Syn-transcurrent K-rich granite along the Dorsal Canguçu Shear Zone

micaceous and therefore appeared to be difficult to identify the origin of micas.

The third outcrop was the top of Sequence II. Conglomerates with boulders of conglomerates and sandstone were observed (Fig. 11). The fourth outcrop was unscheduled stop, sandstone and fine shaley sandstone, with cross lamina structure showing the paleo-current from SSW to NNE. The fifth stop was a panoramic view of the unconformity between the rhythmites of Santa Barbara Basin and the conglomerates of the Itarare Formation of the Gondwana Sequence (Upper Permian) belonging to the Parana Basin sediments. The field trip of this day ended at Porto Alegre where we reached at 9:00 in the late evening.

Late Neoproterozoic Syn-transcurrent Granites

On 23rd August, the sixth and the last day of the excursion, we visited the Neoproterozoic schistose granitic rocks affected by the sinistral strike slip shearing of the Dorsal Canguçu Shear Zone. The first stop was a panoramic view of quartz mylonites, from a hill composed of medium-grained granular reddish K-rich granite with poor mafic minerals.

The second stop was a large exposure (Fig. 12) on creek bed with mylonitized trondhjemitic gneisses carrying xenoliths of metapelitic gneisses and highly deformed dioritic enclaves. The latest cataclasites and possible pseudotachyliite sporadically develop in minor amount. Some S-C structures indicate sinistral sense of movement, although not very conspicuous.

The third stop was on hillside within bush. The outcrop includes big boulders of the oldest syn-transcurrent granodiorite showing magmatic fabric (Fig. 13) by the alignment of long axes of K-feldspar megacrysts and tabular shaped xenoliths of pelitic gneisses. A general trend is estimated to be in ENE and steep, judged from possible *in-situ* boulders.

The fourth stop was at a working quarry of phyllonitic biotite granitic rock showing distinct horizontal foliation. The foliation changes from horizontal to steep with EW trend within 100 meters northwestward from the previous outcrop. Here the rock shows clear signature of the origin to be K-feldspar porphyritic granite. Some pegmatitic portions carry coarse-grained euhedral tourmaline. At about 500 meters southwestward from the above outcrop along the road surface occur mylonitic banded granites with foliations trending N60°E and nearly vertical.

SUMMARY

The area visited is composed of the western Vila Nova Belt which is the Neoproterozoic juvenile accretionary complexes, the central Tijucas Belt which is a Neoproterozoic reworked schist belt of volcanic and sedimentary rocks origin possibly representing a continental magmatic arc, and the eastern Dom Feliciano Belt (*sensu stricto*) which is a Neoproterozoic reworked migmatite-granite terrain with remnants of Paleoproterozoic gneissic blocks. Rocks of these belts are intruded by many late to post orogenic granite masses, and between the first two belts are developed late orogenic Neoproterozoic basin sediments.

We visited some outcrops of all geologic units mentioned above and conducted field observations and rock samples collections. These observations and rock samples will be analyzed in future to obtain a better understanding and to contribute for the improvement of knowledges of the Dom Feliciano Belt.

Acknowledgement

Prof. F. Chemale Jr. invited the senior author to the University Federal of Rio Grande do Sul and gave him valuable informations and new understanding of the Mantiqueira Province. Professor Bley B. Brito Neves of University of Sao Paulo provided the senior author the chance of visiting this interesting mobile belt and facilitated him to improve the understanding of the Brasiliano belts in South America.

Review comments by F. Chemale Jr., S. Yoshikura and M. Santosh on the early draft improved the present paper.

The present visit of the senior author to Brazil was organized as a joint exchange program of Japan Society for the Promotion of Science and Brazilian Academy of Science. The senior author appreciates these two organizations for providing necessary funding.

The present report is a contribution to IGCP-368, IGCP-440, Gondwana Research Group and Gondwana Institute for Geology and Environment. A part of expenses for the present research was defrayed by the Grant-in-Aid, General Scientific Research No. 11304031 of MONBUSHO and the Japan Society for the Promotion of Science.

References

Almeida F.F.M. de and Hasui, Y. (Eds.) 1984, *O Pre-Cambriano do Brasil*. Edgard Blucher, São Paulo, 378 pages.

Babinski, M., Chemale, F. Jr., Hartmann, L.A., Van Schmus, W.R. and da Silva L.C., 1996, Juvenile accretion at 750-700 Ma in southern Brazil. *Geology*, **24**, 439-442.

Babinski, M., Chemale Jr. F., Van Schmus, W.R., Hartmann, L.A., Da Silva, L.C. (1997) U-Pb and Sm-Nd geochronology of the Neoproterozoic granitic-gneissic Dom Feliciano Belt, southernmost Brazil. *J. S Am. Earth Sci.*, **10**, 263-274.

Basei, M.A. Siga, O. Jr., Masquelin, H., Harara, O.M., Reis Neto, J.M. and Preciozzi, P.F. (2000) The Dom Feliciano Belt of Brazil and Uruguay and its foreland domain, the Rio de La Plata craton.: Framework, tectonic evolution and correlation with similar Provinces of southeastern Africa. In: Cordani, U.G. et al. (eds), *Tectonic Evolution of South America*, 31st IGC, Rio de Janeiro, 311-334.

Chemale, Jr. F. (1998) Tectonic evolution of southern Brazil and southern Africa during Neoproterozoic and early Paleozoic. *Abstracts, International Conf. Basement Tectonics*, Ouro Preto, 10-11.

Chemale, F. Jr., Hartmann, L.A. and da Silva, L.C. (1995) Stratigraphy and tectonism of Brasiliano cycle in southern Brazil. In McNaill, M. (ed), *Proceedings volume on Proterozoic Crust and Metallogenetic Evolution, Communications* **10**, Geol. Soc. Namibia, Windhoek, 151-166.

Chemale, F. Jr., Babinski, M., Van Schmus, W.R., Wildner, W. and Lima, E.E. (1997) U-Pb and Sm- Nd isotopic studies of Neoproterozoic to early Paleozoic belts in southern Brazil. *I South American Symposium on Isotope Geology, Campos do Jordan, SP., Brazil, Extended Abstracts*, p.71.

Fernandes, L.A.D., Tommasi, A., and Porcher, C.C. (1992) Deformation patterns in the southern Brazilian branch of the Dom Feliciano Belt: a reappraisal. *J. South Am Earth Sci.*, **5**, 77-96.

Fragoso Cesar, A.R. (1980) O Craton do Rio de La Plata e o Cinturao Dom Feliciano no Escudo Uruguaio-Sul Riogrand ense. *Congr. Bras. de Geol., Anais, SBG, 31, Camboriu*, **5**, 2879-2891.

Frantz, J.C. and Botelho, N.F. (2000) Neoproterozoic granitic magmatism and evolution of the eastern Dom Feliciano Belt in southernmost Brazil: a tectonic model. *Gondwana Res.* **3**, 7-19.

Frantz, J.C. and Nardi, L.V.S. (1992) O Magmatismo Granitico da Regiao Oriental do Escudo Sul-riograndense: *Uma Revisao. Pesquisas*, **19**, 183-189.

Frantz, J.C., Remus, M.D., and Hartmann, L.A. (2000) Geological units, ages and tectonic evolution of the Neoproterozoic Dom Feliciano Belt, southernmost Brazil -A review. *Revista Brasileira de Geosc.*, **30**, 55-57.

Gresse, P.G., Chemale, F., da Silva, L.C., Walraven, F. and Hartmann, L.A., (1996) Late- to post-orogenic basins of the Pan-African-Brasiliano collision orogen in southern Africa and southern Brazil. *Basin Research*, **8**, 157-171.

Hartmann, L.A. and Fernandes, L.A.D. (2000) Crustal evolution of southern Brazil: juvenile accretion and shear zones. *Field Trip Guide, 31st IGC, Rio de Janeiro*, August 2000, 50 pages.

Hartmann, L.A., Leite, J.A.D., Silva, L.D.da, Remus, M.V. D., McNaughton, N.J., Groves, D.I., Fletcher, I.R., Santos, J.O.S. and Vasconcellos, M.A.Z. (2000) Advances in SHRIMP geochronology and their impact on understanding the tectonic and metallogenic evolution of southern Brazil. *Australian J. Earth Sci.*, **47** (5) in press.

Koester, E., Soliani Jr. E, Leite, J.A.D., Hartmann, L.A., McNaughton, N.J., Santos, J.O.S. and Fernandes, L.A. D. (2000) Zircon U/Pb dating of the Neoproterozoic Santana Granite, Porto Alegre, Brazil. *J. S. Am. Earth Sci.* (in press).

Leite, J.A.D., Hartmann, L.A., McNaughton, N.J. and Chemale, F. Jr, (1998) SHRIMP U/Pb zircon geochronology of Neoproterozoic juvenile and crustal-reworked terrains in southernmost Brazil. *International Geology Review*, **40**, 688-705.

Machado, N., Koppe, J.C. and Hartmann, L.A., (1990) A late Proterozoic U-Pb age for the Boçoroca Belt, Rio Grande do Sul, Brazil. *J. South Am. Earth Sci.* **3**, 87-90.

Porada, H.R. (1979) The Damara-Ribeira Orogen of the Pan-African-Brasilian cycle in Namibia (southwest Africa) and Brazil as interpretation in terms of continental collision. *Tectonophysics*, **57**, 237-265.

Porcher, C.C., McNaughton, N.J., Leiter, J.A.D., Hartmann, L.A. and Fernandes, L.A.D., (1999) Idade SHRIMP em zircan: vulcanismo acido do Complexo Metamorfisco Poraongos. In: *SBG/Nucleo RS I Simposio sobre Vulcanismo Ambientes Associados, Boleti de Resumos*, 110.

Porcher, C.C., McNaughton, N.J., Leite, J.A.D., Hartmann, L.A. and Fernandes, L.A.D. (2000) Geochronology of Proterozoic basement-cover relationships in the southern Brazillian Porongos Belt. *J. S. Am. Earth Sci.* (submitted).

Remus, M.V.D., McNaughton, N.J., Hartmann, L.A. and Fletcher, I.R. (1999) U-Pb SHRIMP zircon dating and Nd isotope data of granitoids of the São Gabriel Block, southern Brazil: evidence of an Archaean/Paleoproterozoic basement. *Abstracts, Second International Symposium on Granites and Associated Mineralizations*, 271-272,

Remus, M.V.D., McNaughton, N.J., S. A. Hartmann, L.A., Koppe, J.C., Fletcher, I.R., Groves, D.I. and Pinto, V. M. (1999) Gold in the Neoproterozoic juvenile Bossoroca Volcanic Arc of southernmost Brazil: isotopic constraints on timing and sources. *J. S Am. Earth Sci.*, **12**, 349-366.

Silva, L.C. Da, Hartmann, L.A., McNaughton, N.J. and Fletcher, I.R. (1999) SHRIMP U-Pb zircon dating of Neoproterozoic granitic magmatism and collision in the Pelotas Batholith, southernmost Brazil. *International Geology Rev.,* **41**, 531-551.

Silva, L.C. Da, Hartmann, L.A., McNaughton, N.J., Fletcher, I.R. (2000) Zircon SHRIMP dating of a Neoproterozoic overprint in Paleoproterozoic granite-gneiss terrenes, southern Brazil. *Am. Mineralogist,* **85**, 649-667.

Soares, M.R., Hartmann, L.A., Steele, I.M., and Newton ,R. C. (1998) Dehydration melting of a natural metatonalitic rock -Experiments at high pressures and temperatures. *Anais da Academia Brasileira de Ciencias,* **71**, 79-87.

Soliani Jr. E., 1986, *Os dados geochronologicos do Escudeo Sul-Riograndense e suas implicossoes de ordem geotectonica.* Inst. Geosc., Univ. Sao Paulo, Sao Paulo, Tese de Doctoramento, 239 pages.

Trouw, R., Heilbron, M., Ribeiro, A., Paciullo, F., Valeriano, C.M., Almeida, J.C.H., Tupinamba, M. and Andreis, R.R., 2000, The central segment of the Ribeira Belt. In: Cordani, U.G. et al. (eds), *Tectonic Evolution of South America*, 31st IGC, Rio de Janeiro, 287-310.

Manuscript received December 4, 2000.
Revised manuscript accepted February 10, 2001.